ESCAPING ATTENTION: DIGITAL MEDIA HARDWARE, MATERIALITY AND ECOLOGICAL COST

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Discussions of the attention economy have largely centred on ways in which networked digital media technologies afford new forms of attention. While performing crucial work in demarcating the social effects of technology, and examining the commodification of these attentional forms, such approaches have largely ignored the ecological and social costs of the material infrastructure which underlies the attention economy.

Rhetorics of virtuality and informationalisation from attention economy theorists such as Michael Goldhaber suggest that contemporary economies have shifted from material production into a postindustrial or cognitive mode of capitalism. The reality however, is that the microelectronics hardware which enables the construction of the attention economy, presents material social and environmental justice issues which have thus far received scant attention within media and communication studies. This paper draws attention to some of these issues, such as: the usage of Congolese conflict derived tantalum in microelectronics devices, the working conditions in manufacturing complexes where hardware is assembled, the rapidly rising energy costs required to manufacture and power digital infrastructure, and the global trade in highly toxic e-waste.

This paper will mobilise an ecological conception of media and materiality stemming from the work of Gregory Bateson and Felix Guattari, arguing that if we are to take generational responsibilities regarding social and environmental justice seriously, we need to look beyond content in order to critically engage with the materiality of the technologies that digital media is predicated upon.

The Attention Economy and Virtuality

Whilst the notion of an information economy is fairly well established, attention economy theorists such as Michael Goldhaber contend that economies are governed by scarcity, entailing that information cannot be the basis for the contemporary economy, as information and communication technologies (ICTs) have created an abundance of information. Instead, as volumes of information grow at breakneck speeds, the resource which becomes increasingly scarce, and thus becomes a driving force of the economy, is purported to be attention. For Goldhaber (1997), the attention economy represents 'a new natural economy', in which 'a material economy falls victim to its own success.' Similarly Georg Franck (1999) argues that industrial capitalism has been replaced by a 'mental capitalism,' which emerged from industrial production, within which 'the tendency of de-materialisation has for quite some time taken hold of the economic process as a whole.' According to these accounts then, the attention economy supposedly centres upon postindustrial processes that escape materiality or material production, resting instead upon virtualised information flows and the attentional capacities of the human subject. This article seeks to re-evaluate the status of materiality within the attention economy, contending that adopting a materialist approach focussed on the flows of energy and matter surrounding digital architectures is crucial to understanding the ecological costs and ethical imperatives surrounding the attention economy.

Considering the technological assemblage which affords the dissemination of information, we see that far from becoming dematerialised or virtual, the attention economy is in fact predicated on a vast array of matter and energy, and is entangled with the globalised networks of contemporary capitalism. Assemblage theory is proposed as a useful methodological tool for exploring technology, as is posits that systems cannot be entirely reduced to their parts (micro-reductionism) or presented as holistic/emergent totalities (macro-reductionism). Consequently, examining assemblages involves exploring networked phenomena which are dependent upon both the qualities (internal relations) and capacities and affordances (relations of connectivity) realised between constituent parts. Assemblage theory provides further utility in an ecological investigation of the materiality of media systems through positing all material systems as part of a single plane of immanence, connecting flows of matter and energy between natural and technological/cultural spheres.

For example, consider the apparently straightforward task of watching a video on a streaming internet video site such as Youtube or Vimeo, which exemplifies the type of attentional exchange on which the attention economy is supposedly predicated. The information from which the Youtube clip is comprised typically begins as light and sound waves in a particular set of circumstances and geographical location. Light waves are focussed through a lens onto a sensor, either a charged coupled device (CCD) or complementary metal-oxide-semiconductor (CMOS) within a digital video camera (either a discrete device, or one which exists as part of a smartphone or similar multi-purpose device). The sensor, which is split into numerous discrete pixels, accumulates electrical charge proportional to the intensity of light falling onto each pixel, which is converted into a voltage, with each pixel's voltage stored to compose a single frame, and the video stream consisting of a given number of frames per second. Alongside the image, audio is captured through a similar process whereby sound waves are converted into an electrical signal which is then transcoded into binary data representing the amplitude of the audio waveform at regular temporal intervals. The audiovisual dataset is stored magnetically or electronically, either on a solid state device such as an SD or P2 card, a hard disk drive, or digital video tape, before typically being transferred to a computer's hard disk drive. The data stream can then be edited (manipulated, reduced or added to) and exported (re-encoded, typically with additional compression). This requires a computing device with sufficient processing speed, graphical processing power, RAM, hard drive space, and a form of display technology, such as a liquid crystal display monitor.

The video is then ready to be uploaded, requiring a network card, modem and broadband internet connection, allowing the binary data to be sent through the physical conduits of the Internet: networks of copper wire, fibre optic cable, internet exchange points and network switches, through which the binary data is transported over vast geographical distances as electricity or light. Next the binary data reaches the thousands of computers used as servers by companies such as Youtube, which store the 150 million+ videos hosted on the website on hard disk drives containing the sequences of binary code in physical form: as discrete magnetised regions on hard disk platters, with the magnetic charge of each region indicating a one or a zero. These regions are read and altered by a read-write head that scans the platters and can alter the magnetic charge of each region while the three and a half inch platters spin at speeds of approximately 7200 revolutions per minute. Each discrete region represents one byte of storage, with current hard disks regularly containing up to 2 terabytes, or 2199023255552 bytes. While the microscopic scale at which this data exists is thoroughly alien to humans, unlike say the photographs which compose 35mm film, the technology is still entirely material, physical and real; there is nothing virtual or dematerialised about it. Having reached YouTube's servers and been re-encoded in a heavily compressed file format which affords streaming via broadband internet connections, the data can then be streamed to the viewer's computer, again passing through the physical architecture of the Internet before reaching the viewer's own assemblage of microelectronics hardware. The apparently simple task of watching a YouTube video is in fact a complex process predicated upon a vast array of networked and densely interconnected contemporary microelectronics based technologies. These technologies comprise the physical layers of the attention economy, and as with all material infrastructures, involve ecological costs associated with the materials deployed, which raises questions regarding what these costs are, where and upon whom they fall and how they can be reduced.

Ecology is employed here not to denote purely environmental concerns, as in certain conservationist approaches, but along the lines delineated by Gregory Bateson and Felix Guattari to explore interconnection, relationality, and affordances between entangled phenomena which occur at subjective, social and environmental scales. Central to this model of ecology is the concept of distributed cognition, which Bateson utilises to rebuild epistemology from a perspective informed by systems theories. Bateson contends that individual humans, the societies they inhabit, and the ecosystems around them, are complex nonlinear systems characterised by mutualism and interdependency; there are no individual human minds or beings, as these are always part of scalar assemblages and ecologies ranging from the microbiota within each individual's gut through to cultural practices and technologies which evolve over durations far longer than an individual lifetime. Consequently, the human mind is immanent in pathways beyond the boundaries of the body, reaching into both society and the nonhuman environment. Within such a systemic epistemology, the separation of ecologies into mental, social, and environmental scales does not imply hierarchy or separation: it presents a series of related apertures for examining the same, densely interconnected world.

Bateson contends that the epistemological error of confining the mind to the individual human body or brain has practical consequences for ethics and political action:

> As you arrogate all mind to yourself, you will see the world around you as mindless and therefore not entitled to moral or ethical consideration. The environment will seem to be yours to exploit. Your survival unit will be you and your folks or conspecifics against the environment of other social units. (Bateson, 1972:468)

Indeed, Bateson associates this pathogenic epistemology as the root cause of many of the social and ecological crises wrought by industrial systems, arguing that for effective changes to be implemented, a widespread shift in our way of understanding ourselves via our systemic connections is required.

Currently, ethical concerns within an attention economy framework have largely focussed on questions surrounding the types of subjectivity generated by sustained interactions with ICTs, and whether this marks a shift from deep engagements with texts to a mode of hyper-attention linked with attention deficit hyperactivity disorder (Hayles, 2007). Jonathan Beller (2006) departs from such approaches, providing analysis which situates the attention economy within the broader dynamics of globalised capitalism, criticising Franck and Goldhaber in contending that:

> What drops out of these accounts both here and in the blogosphere which is all abuzz with attention to attention, is the question of the Third World, of the Global South, of the 'planet of slums' as Mike Davis calls it, of the more than 2 billion people who live on less than two dollars a day.

While Beller is entirely correct to highlight the manner in which hyperbole pertaining to the attention economy has tended to ignore the fact that information processing technologies are only available to a financially privileged elite and frequently render the lives of the digitally disenfranchised invisible, he stops short of examining ways that technological architectures underpinning the attention economy are themselves contributors to ecological harms within these impoverished communities.

This article will proceed by exploring a range of ecological costs associated with the lifecycle of the attention economy's microelectronics hardware, beginning with those associated with extracting and processing raw materials, developing through costs associated with contemporary manufacturing processes and the energy costs of ICTs, before examining the global trade in electronics waste: what happens to the millions of devices discarded each year when they are perceived to be obsolete. Having explored a range of impacts caused by ICTs the paper's conclusion will explore what form an ecological ethics for the attention economy may take.

Blood Coltan and Rare Earths

Microelectronics devices consist of a multiplicity of materials, frequently including: silicon, copper, tin, zinc, various plastics, lanthanides, tantalum, gold, acetone, hydrochloric acid, benzene, arsenic, sapphire, and silver. Until recently banned under the EU's restriction of certain hazardous substances in electrical and electronic equipment (RoHS) directive, lead, mercury, hexavalent chromium and polyvinyl bromides were also commonly utilised. Before these substances can be deployed in microelectronics manufacture, they must be extracted from the earth and processed into pure elements and compounds.

The diversity and specificity of the materials used are requirements frequently generated by the affordances of the materials. For example, lanthanides, commonly referred to as rare earth elements (REE), create the strongest type of permanent magnets:

> Small, lightweight, high-strength REE magnets have allowed miniaturization of numerous electrical and electronic components used in appliances, audio and video equipment, computers, automobiles, communications systems, and military gear. Many recent technological innovations already taken for granted (for example, miniaturized multi-gigabyte portable disk drives and DVD drives) would not be possible without REE magnets. (US Geological Survey, 2005)

Considering processes of extraction connects the "virtual" reality of digital networks to not only the planet, but also to the globalised flows of energy, human labour, and matter, that compose the 21st century mining and processing industries. These industries undoubtedly produce beneficial effects, providing materials crucial to creating and powering contemporary infrastructures, whilst conferring employment opportunities and associated material wealth upon communities. Without the benefits of extraction industries, contemporary society itself would be dramatically altered, however the processes of extraction used to obtain materials vary widely, and in many instances incur various ecological costs. For example, open cast mining which is frequently employed to extract elements such as copper and zinc involves stripping away the topmost layers of earth to reveal the ores below; a process which necessarily involves the destruction of whichever habitat previously occupied the site. Furthermore, mining operations can produce adverse effects including the contamination of local groundwater, and erosion, such as in Tar Creek, Oklahoma, where local lead and zinc mines left the area so badly polluted and at risk of structural subsidence, that the Environmental Protection Agency ordered an evacuation, declaring the town uninhabitable. REE tend to occur in sites containing radioactive elements, which can create substantial damage if the tailings – the waste product of the initial stage of separating REE from surrounding material – are not properly disposed, (Bourzac, 2010) with tailings from illegally founded REE mines in China having poisoned local water supplies, leading to the eradication of fish stocks and crops (Yong-Tim, 2008).

From an eco-ethical perspective, these cases begin to ask questions about ICT devices, as we see that the extraction of materials used to create digital infrastructures cause serious harms and incur substantial costs to human and other biotic communities. To what extent can we justify damages to these ecological systems based on the socio-economic benefits that digital culture brings? Can the economic benefits of mining be seen to compensate for social impacts? What kind of status do we afford the nonhumans whose ecosystems are damaged by these activities, and how can we evaluate nonhuman costs in relation to social benefits?

A further example that brings the stakes of digital materiality into a sharper political and ethical focus is the procurement of coltan ore for the extraction of tantalum. Tantalum is primarily used as a powder inside capacitors, due to its volumetric efficiency – a crucial quality for technologies such as mobile phones and laptops where size is a paramount design concern – and durability, as unlike electrolytic capacitors, tantalum capacitors do not lose capacitance over time. According to Engineer's Edge (2011) 'The widespread use of tantalum capacitors in cell phones is one of the key factors in the significant reduction in the size of these devices during the past several years.' While tantalum is mined in numerous parts of the world, notably Australia, Brazil and China, controversy arises from the coltan– a contraction of columbium -tantalum, the local tantalum containing ore– industry in the Democratic Republic of Congo (DRC). Evidence suggests that central African tantalum production and reserves are between 10-30% of the global total (Papp, 2008; TIC, 2010; Ma, 2009; Nest, 2011), however the reliability of these figures is questionable given the illegal nature of much of the DRC's coltan trade.

According to the International Rescue Committee (2008), a decade of conflict in the DRC has resulted in the deaths of around 5.4 million people, the majority of cases being due to indirect deaths from treatable diseases, which have flourished following the collapse of the economy and healthcare system, with children under the age of five accounting for nearly half these deaths. While this conflict has raged, exports of coltan from the DRC continued, while the neighbouring states of Rwanda and Uganda, neither of which have significant domestic tantalum reserves, have begun exporting coltan, having exploited Congolese reserves while their armed forces controlled parts of the DRC, with Ugandan coltan exports increasing from 2.5 tons before the war in 1997, to 70 tons by 1999 (Essick, 2001). President Kagame of Rwanda has described the war as self-financing (Hara, 2002) chiefly due to mineral exploitation, with the Rwandan army believed to have seized over $62 million worth of coltan from the DRC in 1999 alone. The war in the DRC was instigated by a multitude of factors including the legacy of the Mobutu dictatorship which was overthrown in 1997, pre-existing ethnic tensions, and an influx of refugees from Rwanda, some of which were implicated in the Rwandan genocide of 1994:

> While political and strategic factors were important at the start of the conflict, all armed groups turned to revenue raising activities to finance their costly military campaigns. As the conflict wore on, economic interests became a major reason to continue fighting... the Congo war became a conflict in which economic agendas became just as important as other agendas, and at times more important than other interests. (Nest, 2011: 76)

In addition to the human costs of the conflict, there are numerous environmental issues associated with coltan mining in the DRC. The Okapi Wildlife Reserve, a world heritage site, has suffered incursions from thousands of artisanal coltan miners, who decimated the animal population after staff were evacuated (Essick, 2001; United Nations Environment Programme 2008). Illegal mining camps in national parks have also led to miners hunting endangered species such as Grauer's Mountain Gorilla (Taylor & Goldsmith, 2002: 421) and elephants (UN 2001) as food. Miners hunt these animals due to a lack of alternative food sources; given the choice between bushmeat from endangered species and starvation it is hard to blame the miners for feeding themselves. Problems of starvation are linked to land use change surrounding agricultural land converted into artisanal coltan mines:

> In Numbi in Kalehe the massive destruction of former grazing land is catastrophic. Soil which has been used for unplanned prospection and artisanal coltan mining is no longer usable for agriculture. Entire hills and valleys have been turned into giant craters, turning the landscape of the region into an expanse of naked earth, at the bottom of which flow rivers and streams which were diverted for the requirements of coltan mining. (Tegera, 2001: 20)

This exhibits one way in which social and environmental ecological impacts are heavily interconnected, with social malaise resulting in environmental issues, which feed back into further social issues, particularly when ecosystems are damaged through deforestation and soil erosion, preventing a return to agricultural activities.

Primarily due to the activities of several NGOs in publicising the links between coltan and the conflict in the DRC, numerous electronics companies have distanced themselves from tantalum originating from central African nations, however the complexity of the global tantalum trade, whereby coltan mined in the DRC is believed to pass through at least ten intermediaries between extraction and consumption, (Essick, 2001; Ma, 2009) entails minimal transparency and accountability. Each transaction represents another stage of plausible deniability on the part of the new owner, and consequently it is extremely difficult for electronics companies to distinguish whether or not they are using conflict related tantalum.

The example of coltan highlights ways in which the extraction of materials for the global electronics industry can have highly detrimental ecological consequences. This demonstrates all too clearly that the material infrastructure of the attention economy is highly interconnected with flows of materials, energy and capital that comprise contemporary global capitalism. Nevertheless, within these networks not all flows are equal, especially when considering their eco-ethical implications. Conflict derived tantalum originating in the DRC whose sale continues to finance weapons for militias, does not have the same ecological costs as tantalum mined elsewhere. The ethics of the situation are complexified however, when considering that an outright ban on tantalum from the DRC would harm legitimate mining operations within the country, removing one of the few sources of income from impoverished people.

Informational Sweatshops

Once the raw materials for the production of ICT hardware have been procured and refined, the next step in their reconfiguration from ores and minerals into iPods and laptops is the manufacturing process. In the early 21st century, microelectronics production has shifted away from being primarily conducted by corporations who brand and sell products, towards a globalised model, where 'Manufacturing is no longer considered a core competency for market control' (Luthje, 2006: 22). Brand name electronics companies are now largely fabrication free entities which outsource manufacturing to vast complexes in low cost, newly industrialising countries in Asia, Latin America and Eastern Europe. While this shift in industrial microelectronics production can be understood as part of ongoing processes of globalisation, this provides a useful counterpoint to claims that information technologies are becoming postindustrial or de-materialised. Examining the ethics of manufacturing requires discussion surrounding labour rights issues and environmental damages within microelectronics production. Surmising the position that the industry has consistently taken, Sonnenfeld concludes that:

> The industry has aggressively resisted not only government regulation, but also formal, organised, representation of workers' rights and compensation to individuals and communities affected by the toxic substances that have been

> integral to electronics manufacturing and disassembly. (2006: 15)

The transition to a globalised industry based on subcontracting has been accompanied by marked decreases in wages and safety conditions, alongside increased environmental damage caused by companies externalising costs onto local ecosystems (Price, 2010). Indeed, the lack of adequate environmental or labour related regulations are a reason that regions provide attractive locations, as the financial cost of adhering to stricter environmental and labour laws reduces profitability. The levels of environmental damage caused by ICT manufacture can be grasped by considering the 29 sites around Silicon Valley designated as Superfund priority locations by the US Environmental Protection Agency, the highest concentration of seriously contaminated sites within the US (Gabrys, 2011: 1), largely arising as a result of chemicals used in semiconductor manufacture seeping into local ecosystems.

The most recent high profile examples of labour rights abuses in ICT manufacturing pertain to Foxconn, the world's largest manufacturer of electronics components, and the Longhua Science and Technology Park situated in Shenzhen, inside the Guandong province of China which employs between 300,000-400,000 workers. The 2006 scandal began with an exposé in the British Mail on Sunday newspaper (Joseph, 2006) which revealed that workers manufacturing Apple's iPods laboured for 12-15 hours a day, earning £54 per month, with half that figure deducted by the company for food and dormitories. Inside the on-site accommodation, 100 workers occupied each dormitory and visitors were forbidden. These conditions, and the labour cost of manufacturing an iPod nano – £4.20 – were contrasted with the retail price in the UK of up to £179. The controversy provided widespread media coverage which concerned Apple, prompting the company to launch an audit of labour conditions at the plant, finding several breaches of local labour laws or Apple's corporate code of conduct, primarily pertaining to the number of hours undertaken by workers, as the weekly limit of 60 hours work 'was exceeded 35% of the time and employees worked more than six consecutive days 25% of the time' (Apple, 2006). There were also breaches relating to the amount of living space inside dormitories, methods of reporting overtime, the dispute process for workers whose overtime had been underpaid, and ways that management disciplined workers.

The subsequent scandal surrounding Foxconn in 2010 was prompted by the actions of fourteen employees who committed suicide between January and May 2010. These acts were committed by young migrant workers, who like the majority of Foxconn and other electronics manufacturing employees in China, had left agricultural home-towns, migrating to manufacturing centres such as Shenzhen to find better paid work. Confronted with the reality of working excessively long hours, while living in crowded dormitories under a fiercely disciplinary regime, these workers aged between 18 and 25 jumped to their deaths to escape the misery of their lives manufacturing elements of the material infrastructure of the attention economy. Unlike the 2006 scandal, the 2010 controversy focussed primarily upon Foxconn rather than Apple or other contractors (Blanchard, 2010; Hille, 2010), although academic criticism traced accountability back through the networks of production, arguing that 'Leading international brands have adopted unethical purchasing practices, resulting in substandard conditions in their global electronics supply chains' (Chan & Pun, 2010). Companies like Apple typically sign exclusive contracts with subcontractors to manufacture the entire stock of new product lines, which the contract stipulates must be available by a certain date. The penalties for not fulfilling the specified quota of devices by the deadline are severe, so the subcontractor typically enacts extremely high levels of compulsory overtime in order to fulfil the contract.

In response to the adverse publicity, Foxconn announced a series of measures designed to improve worker morale and halt the suicides. The basic rate of pay was increased from 900 to 1200 yuan in June, and then from 1200 to 2000 yuan in October 2010 (Blanchard 2010), the number of compulsory overtime hours was reduced (SACOM, 2010), and workers were asked to sign pledges that they would not kill themselves. The wage increase announced in June can be largely attributed to a rise in the legal minimum wage in Shenzhen to 1100 yuan, meaning that Foxconn's wages remained just above statutory minimum levels (SACOM, 2010), however, the subsequent rise to almost double the legal minimum wage suggests that under the scrutiny of sustained international attention, Foxconn felt forced to take action before the negative coverage translated into consumer or contractor action. While Foxconn in Shenzhen is only one plant in a vast industry, the low wages, poor living conditions and extremely long hours are typical of the global electronics industry.

What is interesting to note about this case, is that the mobilisation of attention, which involved the usage of various ICTs towards the issues of labour rights was in some ways successful in addressing concerns surrounding the production of these devices. This point invokes Bernard Stiegler's argument that technics constitutes a pharmacological situation, whereby contemporary technologies are simultaneously poisonous, and represent the remedy to their own toxicity. Examining the material impacts of these technologies is revealing here, as what could otherwise appear to be a metaphor referring to the toxification of subjectivity, is realised in a strikingly literal way through the exposure of workers to poisonous materials commonplace throughout the life-cycle of microelectronics. For Stiegler, the pharmacological context of technics entails that technologies are neither intrinsically 'good' nor 'bad,' the political affordances of technological systems emanates from the specific ways in which they are employed. Currently Stiegler identifies two alternative methods of employing ICTs, those that promote the destructive short termism of neo-liberal consumer culture, or alternatively as a means for forming economies based upon long circuits of individuation promoting contribution and collaboration, whereby the opposition of producer/consumer which dominates industrial modes of production is overcome.

Whilst Stiegler does not explicitly engage with the ecological costs of ITCs, the notion of replacing the current mode of production and the separation of producers and consumers which frequently sees negative social and ecological impacts of technologies borne by people and ecosystems far removed from sites of consumption does present a potential alternative. Indeed, Stiegler's focus on the notion of an economy of contribution as a system predicated on the combination of inclusive systems of care and the formation of positive externalities can be seen as a remedy to the current tendencies towards separation between producer and consumer alongside the production of negative by a system designed around economic growth rather than ecological wellbeing.

Powering Digital Culture

It borders on tautology to state that ICTs require electricity to power them, but electricity has to be generated somewhere and somehow, and within the contemporary cultural context that predominantly means the combustion of fossil fuels, entailing the release of carbon dioxide and other greenhouse gases into the atmosphere, contributing to anthropogenic climate change, alongside the localised ecological costs of fossil fuel extraction, as dramatically highlighted by events on the BP-owned Deepwater Horizon oil rig in 2010. Recent data suggests that the energy requirements of powering ICTs is substantial and rapidly rising, presenting questions surrounding the ethical and political status of these technologies. Explicating the scope of these issues is required in order to better comprehend what is at stake: by paying attention to the problems posed, we can begin to consider the ethical problematics and formulate programmes for actions designed to remedy issues.

In 2007, estimates indicate that the global ICT industry was responsible for approximately 2% of global anthropogenic carbon dioxide emissions (Gartner, 2007). The energy requirements of ICT are not limited to powering products however, as manufacturing hardware additionally requires high volumes of energy. According to a study undertaken by the United Nations University in 2004, producing a desktop computer and 17inch CRT monitor uses approximately 240kg of fossil fuels, 22kg of various chemicals and 1500kg of water (Williams, 2004). These inputs are similar to those required to manufacture a mid-sized motor vehicle. 81% of the life cycle energy cost of the computer was used in production with only 19% required for operation (Williams, 2004). The ratio occurs partially because of the complexity of the manufacturing processes and the variety of materials and components required, but also due to the highly limited lifespan of media hardware within the cultural context of upgrade culture.

The rapid pace of contemporary technological change entails that obsolescence is often perceived before devices fail to function. For example, the life cycle analysis featured in Williams 2004 cites several surveys suggesting that new computer purchases occur every 2.7-3.4 years, Hoang et al. (2008) similarly calculate that the average life of a laptop is between three and four years. While most computers function beyond these durations, users upgrade to newer, more powerful machines, a process which Hoang et al contend is frequently driven by the introduction of newer versions of software, which demand higher system specifications, resulting in consumers perceiving their hardware to be obsolescent.

Perceived obsolescence is also an issue with mobile phones, which are generally sold on 12-24 month contracts, at the end of which the consumer is offered a new contract, with a free new phone usually offered as an incentive. Despite the old phone still functioning adequately, it is either thrown away or left in a drawer to gather dust. In 2007 the US Environment Protection Agency estimated that 126 million mobile phones were disposed of in the US alone, with only 14 million being recycled. (US EPA, 2007) The vast majority of these devices will have been perfectly functional, but the economic and cultural imperatives of networked capitalism and upgrade culture: to sell more products in order to fuel economic growth and to buy new products in order to increase productivity and cultural kudos, entail that they are perceived as obsolescent and consequently discarded. Given the ecological costs of producing these devices, the practice of discarding functional hardware can be understood as ecologically unsustainable and ethically dubious.

Alongside perceived obsolescence, planned obsolescence is an issue with regards to ICT devices. Planned obsolescence involves corporations designing products with artificially limited lifespans, so consumers frequently replace devices, meaning that microelectronics companies sell more products. For example, numerous mp3 players are designed with sealed battery compartments, preventing easy replacement of the limited life lithium-ion batteries used to power the devices. When the battery fails to hold an adequate charge the device does not perform its function, and so requires replacing, however if the device featured a battery compartment which could be accessed, the consumer could simply replace the battery – a single, low-cost component – while retaining the still-functional mp3 player.

Examining the energy costs throughout the life cycle of ICTs proves useful in delineating that the vast majority of energy is spent producing the hardware, partially due to the limited lifespan of these technologies. Bearing this in mind, it is perhaps unsurprising that Williams (2004) and Hoang et al. (2008) conclude that extending the lifespan of hardware is among the most promising approaches to mitigating energy costs. By simply not discarding functional hardware, consumers can significantly reduce the ecological footprint of their technology. However, as the example of mobile phones illustrates, the corporations producing these technologies are eager for consumption to speed up rather than slow down, deploying a combination of perceived and planned obsolescence in order to reduce product lifespans, which increases ecological costs but also raises short-term profitability.

This highlights the divergence between corporate imperatives driven by economic profitability and the ecological epistemology presented by Bateson. The unit of survival for corporations is the individual company, which competes against all similar companies, viewing social and environmental commons as assets to be appropriated and exploited, or an othered outside onto which ecological costs can be externalised in the quest for profitability. By contrast, Bateson's epistemology calls for the implementation of economic models which value the wider ecological context in which the corporation is embedded. In the ever-intensifying battle between corporate actors for consumer attention and economic growth, broader notions of ecological growth are marginalised, allowing the type of destructive short-termism criticised by Stiegler to flourish. Indeed, from the longer term, ecological perspective such behaviour is ultimately self-defeating:

> If an organism or aggregate of organisms sets to work with a focus on its own survival and thinks that is the way to select its adaptive moves, its 'progress' ends up with a destroyed environment. If the organism ends up destroying its environment, it has in fact destroyed itself. (Bateson, 1972: 457)

Contributing to global ecological crises such as anthropogenic climate change will eventually proves detrimental to corporate profitability, however the short-termism of neo-liberal orthodoxy effectively prevents corporations from taking ecologically-effective action.

E-Waste and Recycling

Safe disposal of microelectronics is not straightforward, as devices contain numerous toxic materials. In 2009, 20-50 million tonnes of electronics waste, commonly referred to as e-waste, were generated globally (Electronics Takeback Coalition, 2011). Furthermore, the volume of e-waste, 'is the fastest growing waste stream and already accounts for 5 percent of all solid waste in the United States, as well as approximately 40 percent of all lead, 70 percent of the heavy metals and a significant proportion of the pollutants in US dumps' (Byster & Smith, 2006: 210). Consequently, both the toxicity and volume of e-waste present further examples of ecological costs associated with the attention economy.

Currently, wealthier nations send large volumes of e-waste to poorer countries, where they are frequently manually processed and treated. It is common for there to be few safeguards for the health and safety of either the workers or the local environment:

> About 80 percent of the electronic wastes collected in North America for 'recycling' actually find their way, quite legally, to dangerously primitive, highly polluting recycling operations in Asia. European recycling insiders have calculated the export figure for their own continent at 60 percent despite European Union laws banning such export. (Puckett, 2006: 225).

Puckett is particularly critical of how rhetorics of recycling, and associated connotations of ecological concern have been co-opted into a system externalising ecological costs onto impoverished people, whose techniques for recovering valuable components within ICT hardware would be illegal in the nations where the product was used.

Under the Basel treaty, adopted in 1989 and amended in 1994, it is illegal for the EU and several other OECD nations to engage in exporting hazardous waste, and illegal for the non-OECD countries to receive hazardous waste, though the treaty was not signed by the United States, Canada, or Australia. More recently, the EU's waste electrical and electronics equipment (WEEE) directive requires all e-waste within the EU to be recycled at local facilities, and retailers must allow consumers to return old EEE products when purchasing replacements. However, a study commissioned by the EC to review the WEEE directive's impact found that between only 25 and 40% of end of life EEE is currently returned and treated under these schemes, leaving substantial room for improvement. The report concludes that 'Increasing consumer awareness is a necessity for an eco-efficient WEEE implementation with maximised environmental results (collect more) and increased costs efficiency (treat better)' (Huisman et al., 2008). This highlights the lack of attention focussed on the issue of e-waste, and how increasing attention and thus awareness is essential for enhancing the impact of existing legislation.

While the WEEE directive and Basel convention exist to prevent a global trade in e-waste, these laws are routinely circumvented through waste management companies shipping e-waste labelled as working, second hand goods for sale in non-OECD countries:

> In Lagos, while there is a legitimate robust market and ability to repair and refurbish old electronic equipment including computers, monitors, TVs and cell phones, the local experts complain that of the estimated 500 40-foot containers shipped to Lagos each month, as much as 75% of the imports are “junk” and are not economically repairable. (BAN, 2005)

Once e-waste has arrived in processing centres it is manually disassembled, with valuable materials such as copper, gold and silver gathered for re-sale. While processes for obtaining these materials vary, they frequently include actions such as burning wires to melt the plastic casing, revealing the valuable copper contained inside. The BAN report notes that: 'Due to the presence of PVC or brominated flame retardants in wire insulation, the emissions from such burning will contain high levels of both brominated and chlorinated dioxins and furans – two of the most deadly persistent organic pollutants' (BAN & STVC, 2002:,18). Acid baths are used to recover metals, such as the gold used in pins which connect silicon chips to circuit boards, with the corrosive leftover product of nitric and hydrochloric acids mixed with the dissolved remnants of the components routinely finding their way into local water tables, rendering the water undrinkable. CRT monitors have the lead-laden glass cracked open so that the valuable copper yoke can be removed, resulting in lead leaching into the ground. When the Basel Action Network tested water from the river in Guiyu, they found it contained lead levels 190 times higher than the maximum level safe for human consumption prescribed by the World Health Organisation (BAN & STVC, 2002: 24).

The workers in e-waste processing zones frequently include children, and wages are often in the region of $US 1.50 a day (Roman & Puckett, 2002: 2).

> Interviews reveal that the workers and the general public are completely unaware of the hazards of the materials that are being processed and the toxins they contain. There is no proper regulatory authority to oversee or control the pollution, nor the occupational exposures to the toxins in the

> waste. Because of the general poverty people are forced to work in these hazardous conditions. (BAN & STVC 2002: 26)

The global trade in e-waste involves affluent countries externalising ecological costs onto the peoples and ecosystems in impoverished areas of the world. In this way, the material architecture of the attention economy detrimentally impacts upon the digital have-nots. Presently existing systems see OECD nations sending vast quantities of hazardous materials to be manually 'recycled' by people who do not comprehend the harms to themselves, their communities, or the local ecosystems wrought by their actions. Drawing attention to this situation, and finding ways of enforcing existing legislation which renders exporting e-waste illegal, becomes a crucial task if adopting an ethical approach to contemporary media technologies is to be taken seriously.

Conclusion

Surveying the ecological costs associated with the life cycle of the microelectronic devices which form the physical layer of the attention economy, reveals that far from being predicated upon dematerialisation or virtuality, the network economy is built upon a series of technologies which are highly intertwined with the globalised systems of contemporary capitalism. Contemporaneous practices regarding these technologies, frequently involve the systemic externalisation of harms onto communities and ecosystems in impoverished areas far from the affluent districts where the technologies are bought and utilised. Within this context, Franck's (1999) honestly intended question, 'Is the economy of attention thus an already practically experienced preliminary stage of future ecologically non-harmful lifestyles?' appears extremely naïve. This does, however, aptly demonstrate the dangerous limitations of approaching the attention economy from a perspective which elides the material foundations of the information society: adopting such a perspective renders ecological costs invisible, thereby preventing engagement and action which can begin to mitigate the harms currently being perpetuated.

Throughout this paper it has been argued that acknowledging the ecological costs of microelectronics requires considering the ethical questions raised by current modes of production, consumption, and disposal. A liberal ethics based on Rawlsian notion of justice would undoubtedly criticise contemporary labour practices, as they are dependent upon enormous material inequalities that are not redressed by the actions of workers poisoning themselves for little financial recompense whilst creating technologies consumed elsewhere. However, such an approach is poorly situated to address the commensurability of benefits to humans and harms to nonhumans.

Consequently, an ecological approach to ethics is posited here as a way of considering the ethical impacts, and consequent urgency for political action on these issues. Following the systemic epistemology suggested by Bateson and Guattari entails reconceptualising ourselves as immanent in systems beyond the confines of our skins, inviting consideration of what types of thinking systems we are collectively creating, as material technological structures are considered part of our cognitive systems. Within this context, ethics moves from considering “good” and “bad” acts based upon essentialised morals, to contingent and contextual truths which are actualised within material assemblages. This does not however, mean that such as position eschews the difference between good and bad: 'The distinction between good things and bad provides the basis for a real ethical difference, which we must substitute for a false moral opposition' (Deleuze, 1992: 253-254). Resultantly, according to Guattari and his frequent collaborator, Gilles Deleuze, an ecological ethics pertains to ways that actions bring the dynamic relations constitutive of an ecological agent into composition with those of other beings and networks, with good acts being those which augment the capabilities of the actors – such as symbiosis and mutualism – while bad acts reduce the capacities or relations of the actors. Undoubtedly, the deleterious effects of ICT manufacture reduce the capabilities of differing forms and scales of actor, ranging from the individual worker poisoned by treating e-waste, through the local ecosystems ravaged by open cast mining, to the global climate which is being altered by anthropogenic activity at a pace that is beyond the adaptive capacity of a multitude of species. Crucial to ecological ethics then, is the move from focussing on human subjects to considering dynamic ecologies of relations between actors, both human and nonhuman.

When considering methods to address these problems via mobilising political action, Guattari contends that:

> The ecological crisis can be traced to a more general crisis of the social, political and existential. The problem involves a type of revolution of mentalities whereby they cease investing in a certain kind of development, based on a productivism that has lost all human finality. Thus the issue returns with insistence: how do we change mentalities, how do we reinvent social practices that would give back to humanity – if it ever had it – a sense of responsibility, not only for its own survival, but equally for the future of all life on the planet, for animal and vegetable species, likewise for incorporeal species such as music, the arts, cinema, the relation with time, love and compassion for others, the feeling of fusion at the heart of cosmos? (1992: 120)

This again highlights the importance of altering mental ecologies via engaging with systems of distributed cognition. An ecological ethics then, does not consider the material implications of ICTs to be separate from issues surrounding the attention economy and modes of subjectivity, it contends that only by reconfiguring attention and subjectivity can these issued be substantively addressed.

Indeed, searching for potential remedies to the ecological costs, several promising avenues arise from mobilising attention towards the ethics of ICTs. The surge in global attention towards Foxconn and Apple regarding working conditions in Shenzhen, led to concrete improvements to the lives of workers. Similarly, Huisman et al.'s (2008) claims that the WEEE directive's impact could be vastly enhanced by increasing consumer awareness, demonstrates that highlighting the material impacts of microelectronics can be a useful strategy in mitigating certain ecological costs. Providing models of materiality which engage with the longer circuits of technology via life-cycles as opposed to the short-term fix of commodities and use-value perhaps represent a way of altering cognitive systems towards an ecological ethics.

A second major area where harms can be minimised, is through the implementation of innovation in the design process: 'True solutions to our toxics crisis lie not in recycling wastes downstream, rather in eliminating them through “green design” upstream' (Puckett, 2006: 226). Designing products that do not contain hazardous substances, which can be easily and safely recycled, which are built to last, and modular in composition, can substantially reduce ecological costs associated with the life cycle of ICTs. The EU's RoHS directive presents an example of design orientated change which has already impacted upon microelectronics production, having effectively eliminated the usage of some of the most toxic materials previously ubiquitously found in microelectronics. Further afield the cradle to cradle movement and the open source hardware/open design communities suggest ways that alternative approaches may in future present methods of creating ICTs in ways which reduce or remove many of the ecological costs incurred by contemporary practices, particularly those surrounding planned and perceived obsolescence. Indeed, the shift from a consumer based mass manufacturing system to the distributed peer-to-peer architecture of the open source hardware (OSH) movement is one way of approaching Stiegler's notion of transitioning from a system of commodification to an economy of contribution:

> The software industry and its digital networks will eventually cause associated techno-geographical milieus of a new kind to appear, enabling human geography to interface with the technical system, to make it function and, especially, make it evolve, thanks to this interfacing: collaborative technologies and free license software rest precisely on the valorization of such associated human milieus, which also constitute techno-geographical spaces for the formation of positive externalities... Such forms of knowledge and their valorization are the only possibilities we have for struggling against the production of information without knowledge. Developing such forms of knowledge and valuing them economically will cause a new economic system to emerge from the heart of social systems, and respecting these social systems means constituting an economy of contribution, contra the economy of carelessness. (Stiegler, 2010: 128-129)

OSH provides a pertinent example of this form of transition, as it provides evidence whereby the mode of distributed, peer-to-peer production which originated with free software and is claimed by informational exceptionalists such as Yochai Benkler (2006) to relate solely to nonrival goods, is applied to rival goods ranging from washing machines to 3D printers. Additionally, by providing open access to design-related data, OSH resists the struggle against the loss of communal knowledge of how to create and sustain socio-technical systems which otherwise becomes the intellectual property of multinational corporations, whose economic interest is to produce information without knowledge: the contemporary situation of information excess accompanied by a lack of awareness regarding the detrimental ecological impacts of ICTs explored within this paper.

Both the formation of the distributed peer to peer networks which comprise open source hardware communities, and the strategies for utilising networked digital telecommunications to garner attention and raise awareness of these issues, highlight the pharmacological context of contemporary technics, whereby the devices which ostensibly are the causes of these detrimental ecological impacts, simultaneously present the most promising pathways to remedying these same problems. Adopting these solutions however, is predicated upon a materialist approach to the technologies underpinning the attention economy. Only by paying attention to, and making visible the materials and techniques involved, and the varying impacts and costs they incur, can we collectively begin to design cognitive, social, and mnemotechnical systems geared towards social justice and ecological resilience.

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